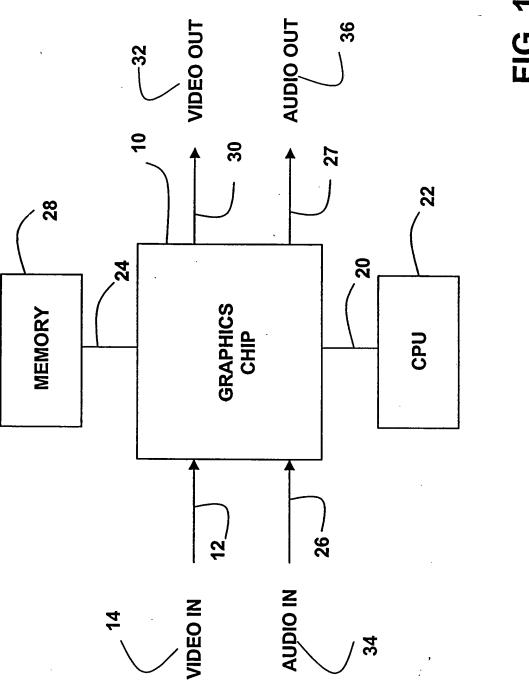Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 1 of 37

VIDEO OUT 32

AUDIO OUT 36

10

30

27

28

MEMORY

24

GRAPHICS CHIP

20

22

CPU

12

26

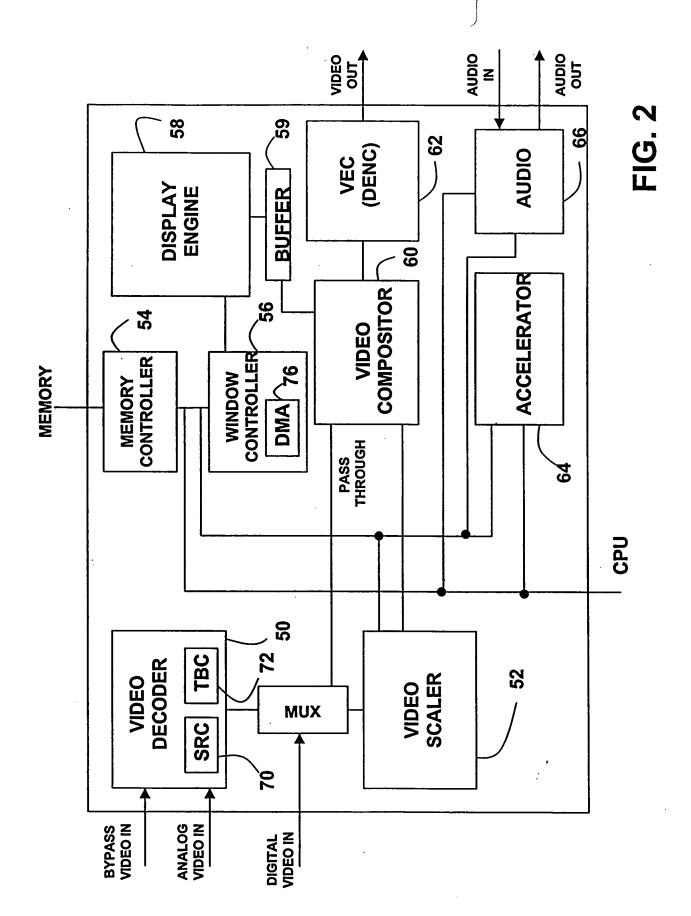VIDEO IN 14

AUDIO IN 34

FIG. 1

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 2 of 37

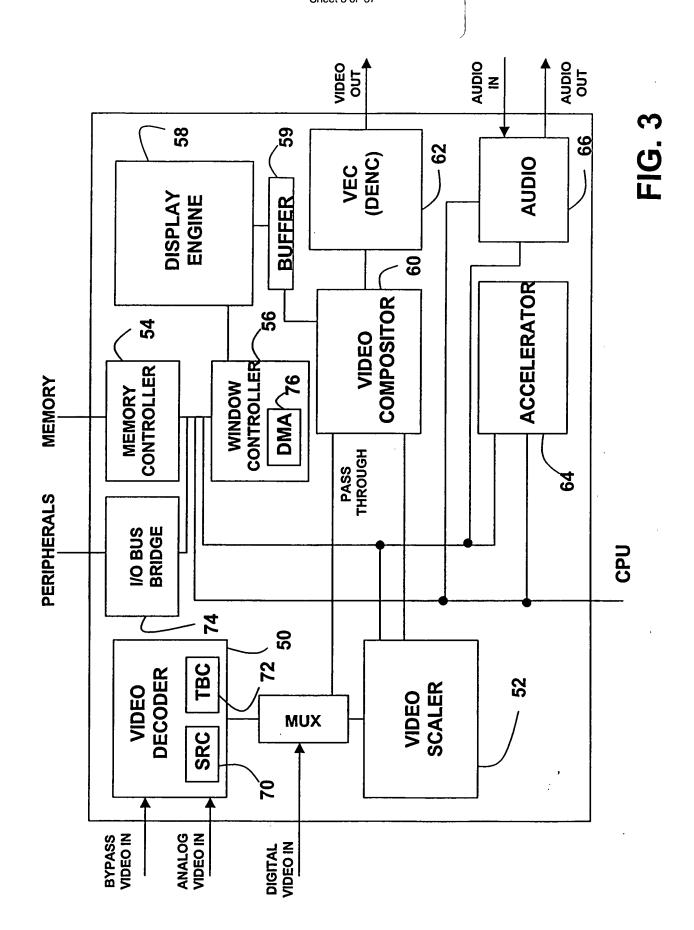FIG. 2

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 3 of 37

VIDEO OUT

AUDIO IN

AUDIO OUT

MEMORY

PERIPHERALS

DISPLAY ENGINE — 58

BUFFER — 59

VEC (DENC) — 62

AUDIO — 66

MEMORY CONTROLLER — 54

WINDOW CONTROLLER — 56

DMA — 76

VIDEO COMPOSITOR — 60

ACCELERATOR — 64

I/O BUS BRIDGE

PASS THROUGH

VIDEO DECODER — 74

TBC — 72

SRC — 70

50

MUX

VIDEO SCALER — 52

CPU

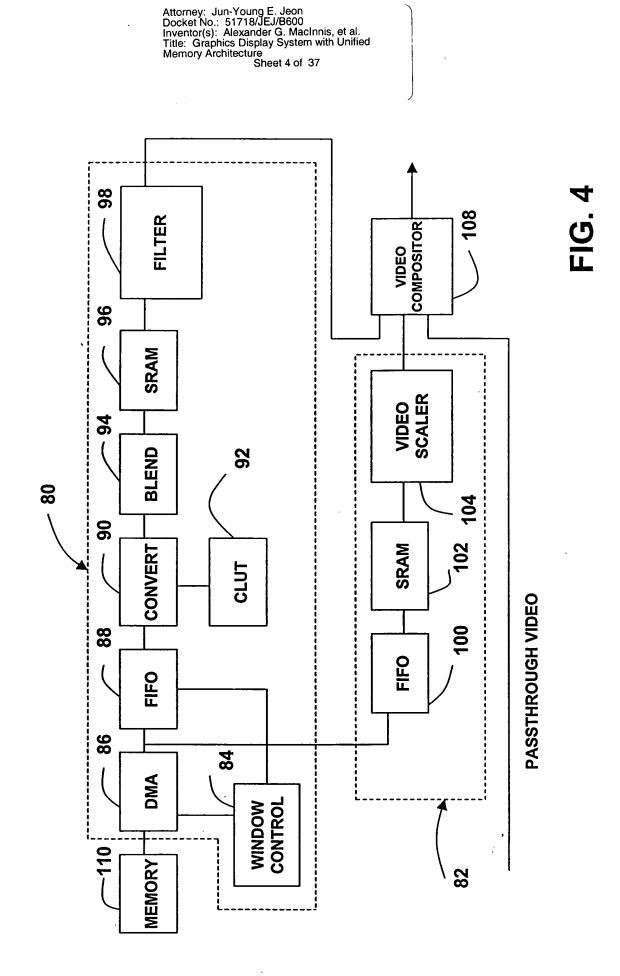BYPASS VIDEO IN

ANALOG VIDEO IN

DIGITAL VIDEO IN

FIG. 3

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 4 of 37

FIG. 4

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 5 of 37

FIG. 5

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 6 of 37

FIG. 6

WINDOW OPERATION [31:30]

WORD 0

WIN FORMAT [29:26]	WINDOW MEMORY START [25:0]

WORD 1

WIN LAYER [31:28]	WINDOW MEMORY PITCH [27:16]	WINDOW COLOR [15:0]

WORD 2

ALPHA TYPE [31:30]

WINDOW ALPHA [29:22]	H D	WINDOW Y-END [20:11]	H D	WINDOW Y-START [9:0]

WORD 3

WINDOW FILTER ENABLE [26]

NOT USED [31:27]	BLANK START PIXEL [25:22]	H D	WINDOW X-SIZE [20:11]	H D	WINDOW X-START [9:0]

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 7 of 37

8 WINDOW DESCRIPTORS

300h
300g
300f
300e
300d
300c
300b
300a

WDO

WD PARAMETERS

MUX — 302

SMALLEST WD
PARAMETERS

SORTING — 304

SMALLEST WD
PARAMETERS

DMA — 306
(ASSEMBLE
HEADER AND
REQUEST MEM-
ORY DATA)

WD HEADER,
GFX DATA

GFX
FIFO — 308

WD HEADER,
GFX DATA

GFX
DISP

MEMORY CONTROLLER

FIG.7

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
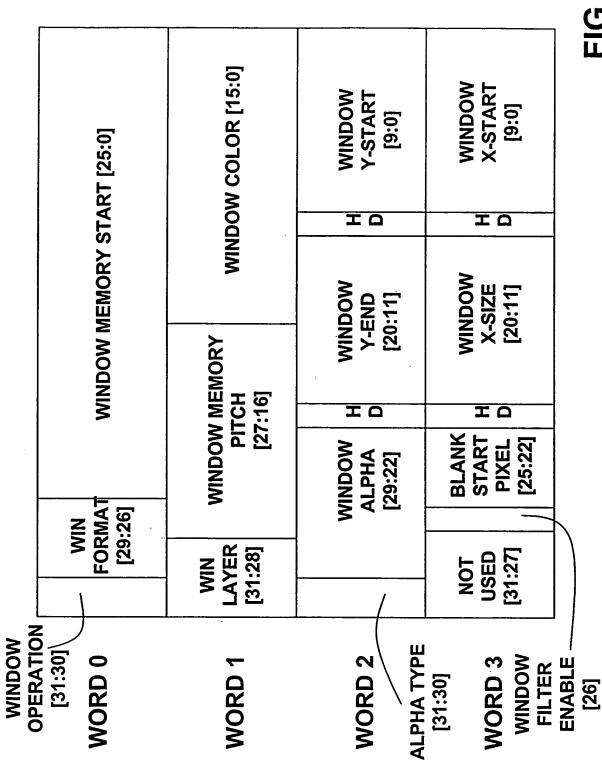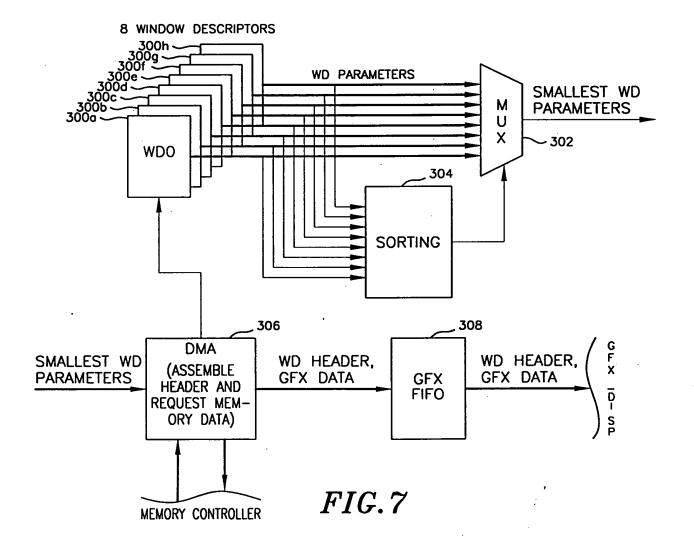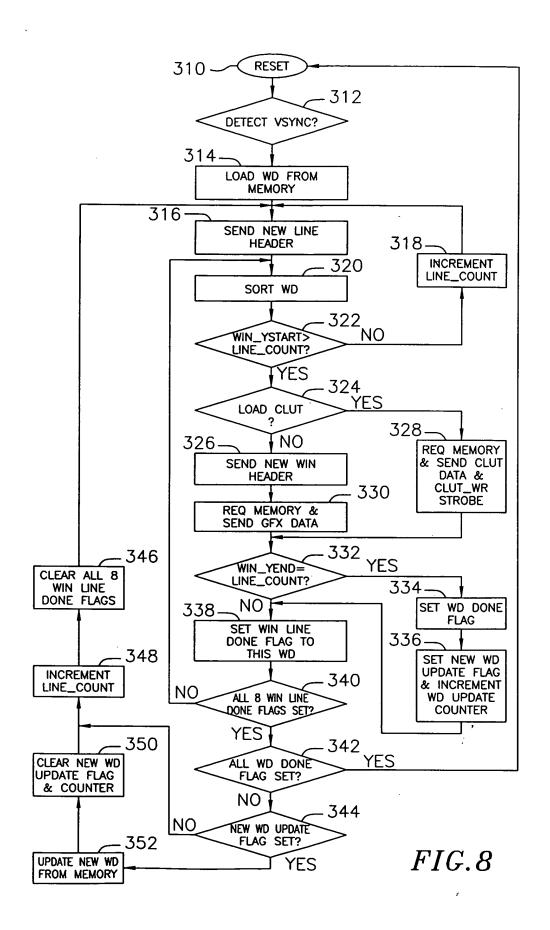Memory Architecture
Sheet 8 of 37

310 — RESET

312 — DETECT VSYNC?

314 — LOAD WD FROM MEMORY

316 — SEND NEW LINE HEADER

318 — INCREMENT LINE_COUNT

320 — SORT WD

322 — WIN_YSTART> LINE_COUNT?   NO

YES

324 — LOAD CLUT ?   YES

NO

328 — REQ MEMORY & SEND CLUT DATA & CLUT_WR STROBE

326 — SEND NEW WIN HEADER

330 — REQ MEMORY & SEND GFX DATA

332 — WIN_YEND= LINE_COUNT?   YES

NO

334 — SET WD DONE FLAG

336 — SET NEW WD UPDATE FLAG & INCREMENT WD UPDATE COUNTER

338 — SET WIN LINE DONE FLAG TO THIS WD

346 — CLEAR ALL 8 WIN LINE DONE FLAGS

340 — ALL 8 WIN LINE DONE FLAGS SET?   NO

YES

348 — INCREMENT LINE_COUNT

342 — ALL WD DONE FLAG SET?   YES

NO

350 — CLEAR NEW WD UPDATE FLAG & COUNTER

344 — NEW WD UPDATE FLAG SET?   NO

YES

352 — UPDATE NEW WD FROM MEMORY

FIG.8

GFX_HEADER 1 — 354

FIRST WINDOW ? — 356

NO

YES

CLOCK SWITCH — 358

YES

GFX_TYPE = 1111 ? — 360

NO

GFX_HEADER 2 — 362

GFX_CONTENT — 364
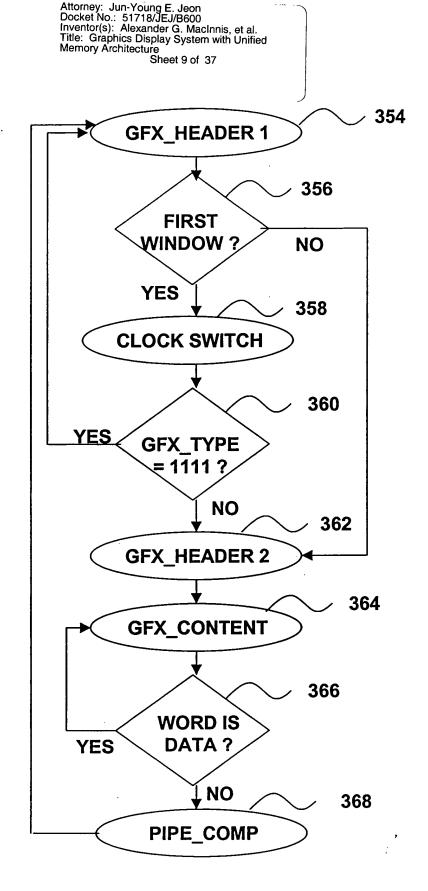
WORD IS DATA ? — 366

YES

NO

PIPE_COMP — 368

FIG. 9

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 10 of 37

FIG. 10

GRAPHICS LINE BUFFER

374

376

58

138 — YUV 444 TO YUV 422 CONVERTER

140 — GRAPHICS BLENDER

134 — GRAPHICS CONVERTER

136 — RGB TO YUV CONVERTER

132 — GRAPHICS FIFO

CLUT

372

370 — MEMORY

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
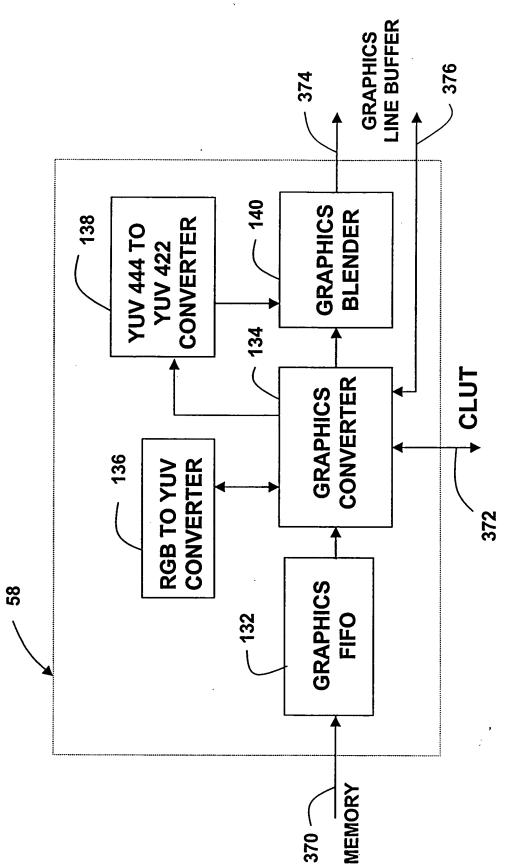Memory Architecture
Sheet 11 of 37

FIG. 11

READ
ADDRESS

412

414

READ
DATA

146

GRAPHICS
CLUT
CONTROLLER

400

SRAM

402

408

CLUT MEM REQ

CLUT MEM WRITE

CLUT MEM DATA

404

410

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
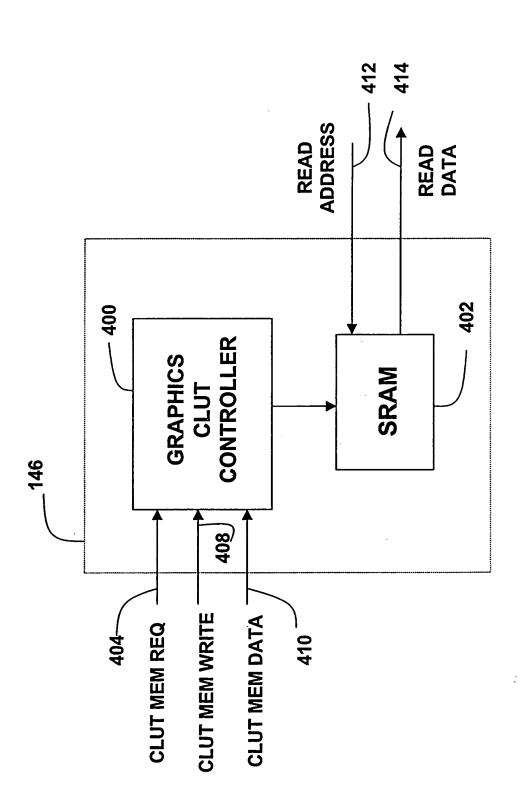Memory Architecture
Sheet 12 of 37

MEMORY CLOCK

416

CLUT MEMORY REQUEST

418

CLUT MEMORY WRITE

420

CLUT MEMORY DATA

422

FIG. 12

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
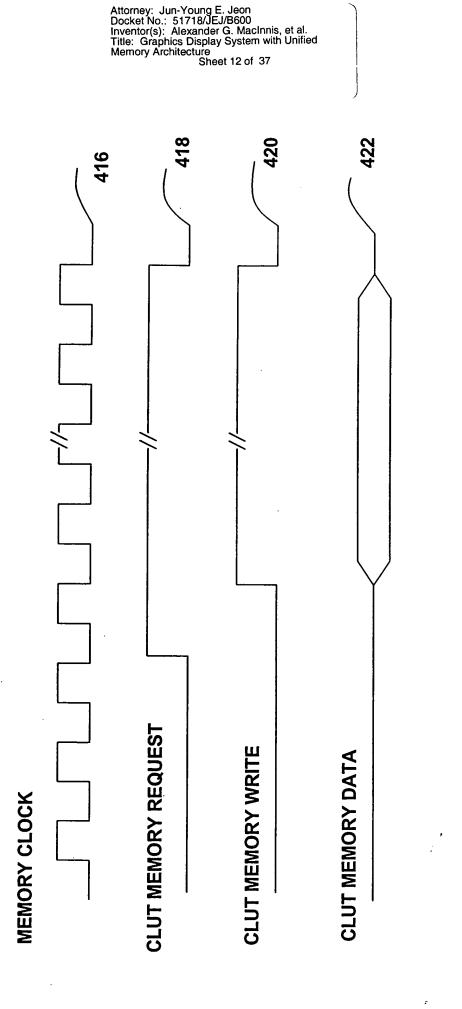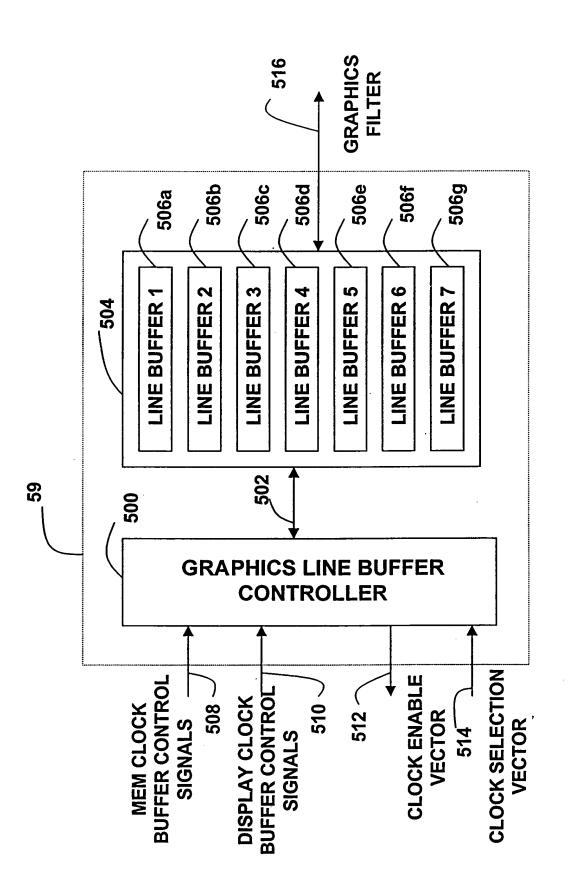Memory Architecture
Sheet 13 of 37

516

GRAPHICS
FILTER

59

504

506a

506b

506c

506d

506e

506f

506g

| LINE BUFFER 1 |
| LINE BUFFER 2 |
| LINE BUFFER 3 |
| LINE BUFFER 4 |
| LINE BUFFER 5 |
| LINE BUFFER 6 |
| LINE BUFFER 7 |

502

500

GRAPHICS LINE BUFFER
CONTROLLER

MEM CLOCK
BUFFER CONTROL
SIGNALS   508

DISPLAY CLOCK
BUFFER CONTROL
SIGNALS   510

512

CLOCK ENABLE
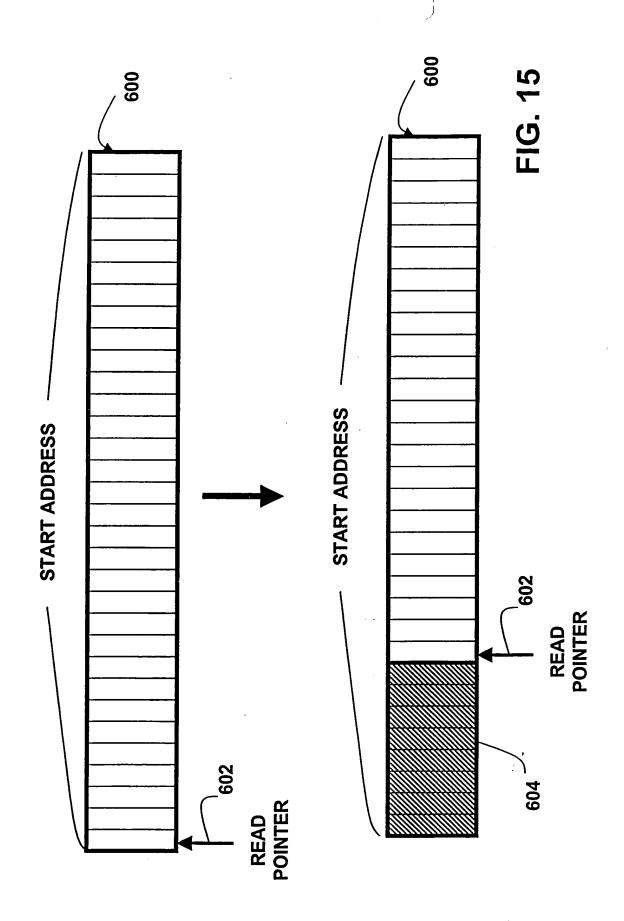VECTOR   514
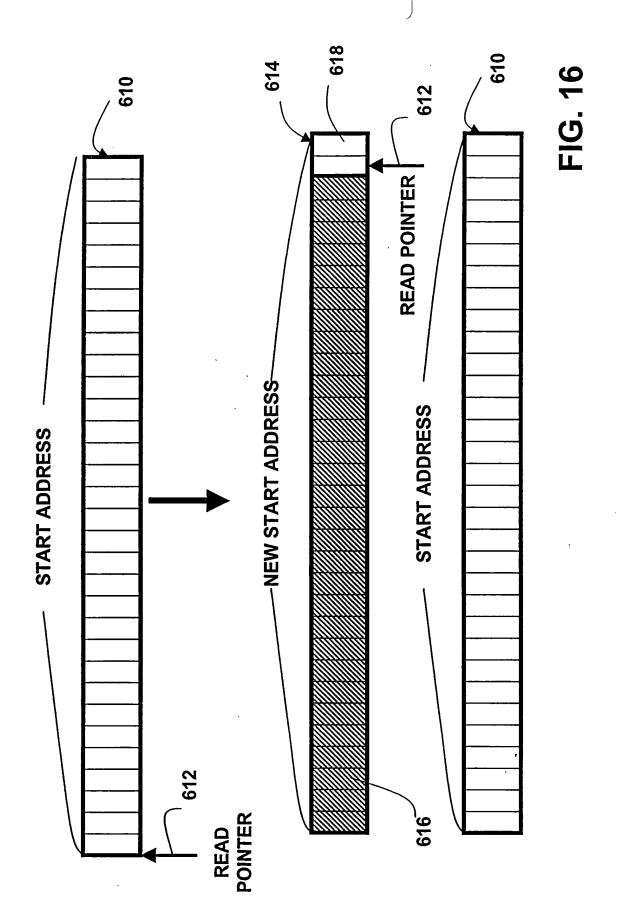
CLOCK SELECTION
VECTOR

FIG. 13

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 14 of 37

RESET — 520

DETECT VSYNC ? — 522

YES

RESET LINE BUFFERS — 524

LOAD LINE BUFFERS WITH GRAPHICS — 526

DETECT HSYNC ? — 528

YES

CLOCK SWITCHING — 530

LINE BUFFERS RELEASED — 532

CLOCK SWITCHING — 534

LINE BUFFERS TO GFX FILTER — 536

DETECT VSYNC ? — 538

YES

NO

FIG. 14

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 15 of 37

600

START ADDRESS

602

READ
POINTER

600

START ADDRESS

602

READ
POINTER

604

FIG. 15

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 16 of 37

610

614

618

612

610

START ADDRESS

NEW START ADDRESS

READ POINTER

START ADDRESS

612

READ POINTER

616

FIG. 16

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
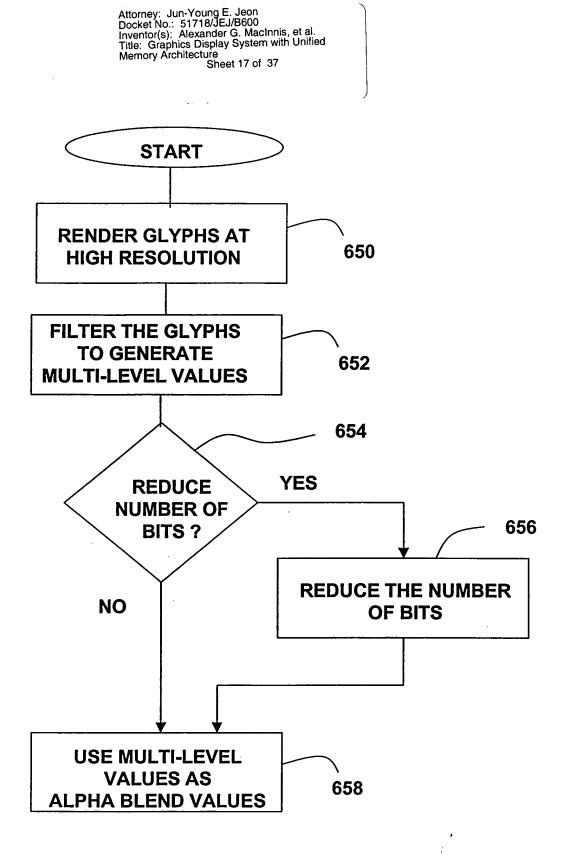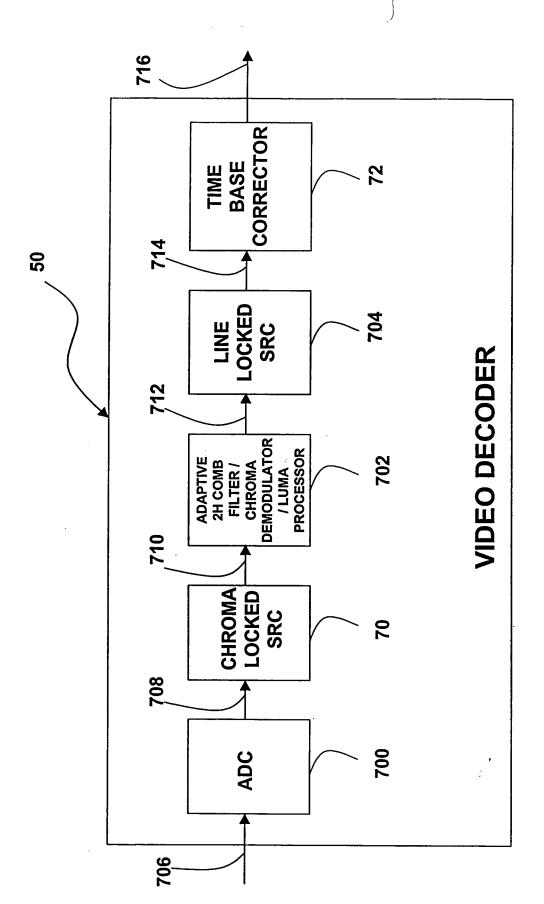Memory Architecture
Sheet 17 of 37

```
                    ┌─────────────┐
                    │    START    │
                    └──────┬──────┘
                           │
              ┌────────────────────────┐
              │   RENDER GLYPHS AT      │── 650
              │   HIGH RESOLUTION       │
              └────────────┬───────────┘
                           │
              ┌────────────────────────┐
              │   FILTER THE GLYPHS     │── 652
              │   TO GENERATE           │
              │   MULTI-LEVEL VALUES    │
              └────────────┬───────────┘
                           │        654
                         ╱   ╲
                       ╱       ╲      YES   ┌───────────────────┐
                     ╱  REDUCE   ╲──────────│ REDUCE THE NUMBER │── 656
                     ╲ NUMBER OF ╱          │    OF BITS        │
                       ╲ BITS ? ╱           └─────────┬─────────┘
                         ╲   ╱                         │
                     NO    │                           │
                           │                           │
              ┌────────────────────────┐               │
              │   USE MULTI-LEVEL       │── 658         │
              │   VALUES AS             │◄──────────────┘
              │   ALPHA BLEND VALUES    │
              └────────────────────────┘
```

FIG. 17

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
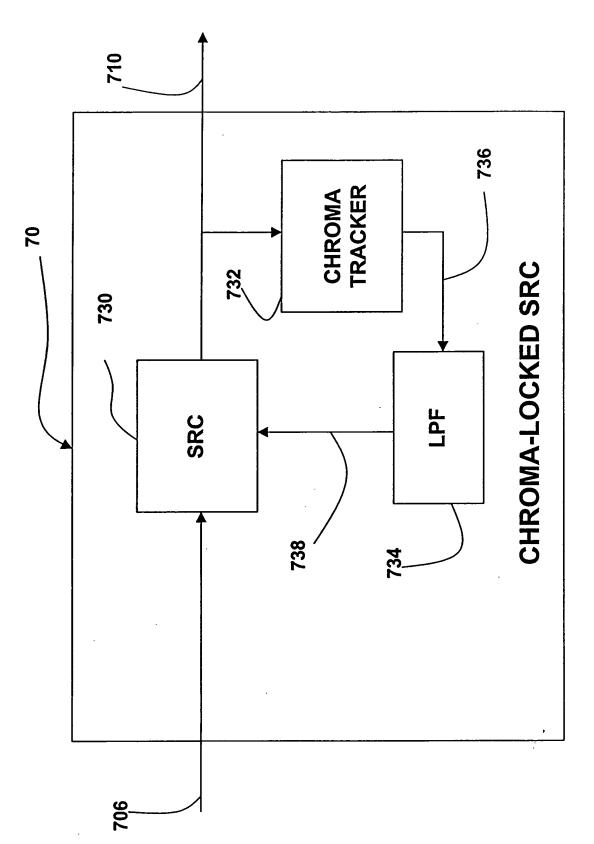   Sheet 18 of 37
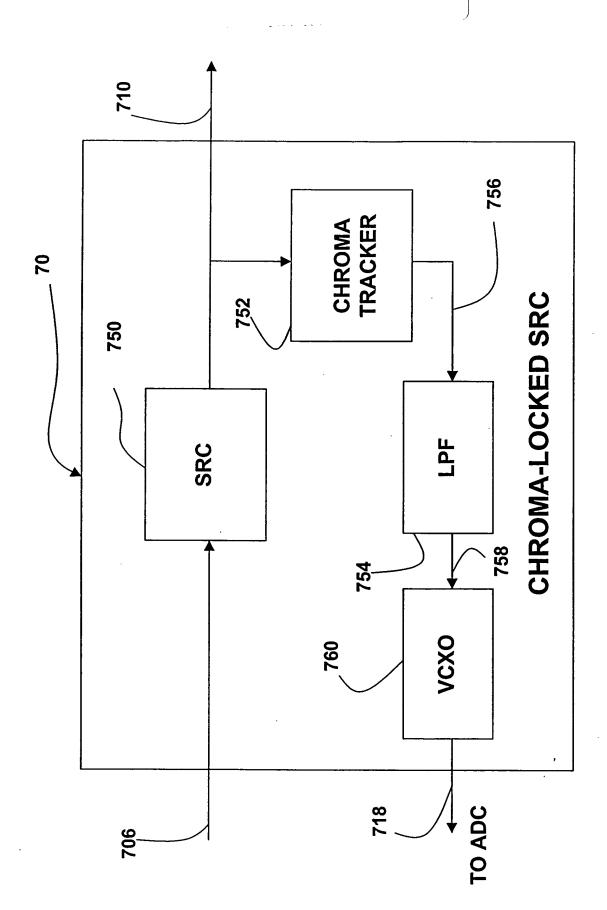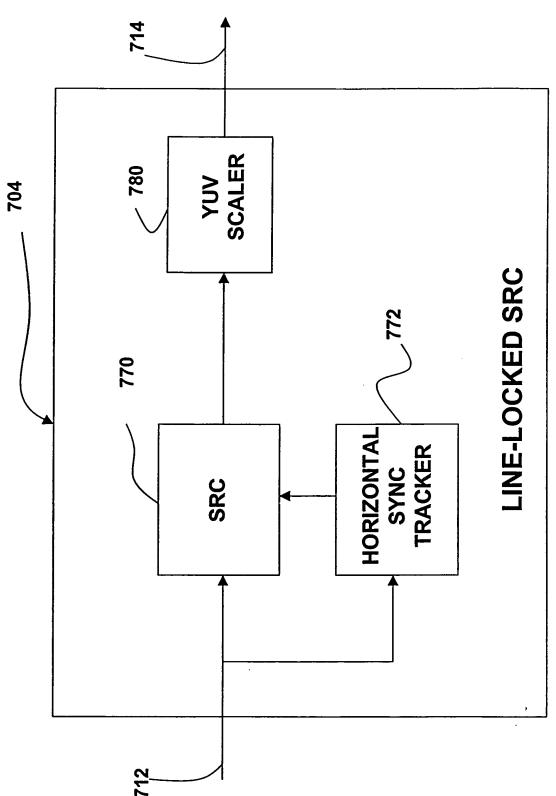
716

50

706

VIDEO DECODER

ADC — 700

708

CHROMA LOCKED SRC — 70

710

ADAPTIVE 2H COMB FILTER / CHROMA DEMODULATOR / LUMA PROCESSOR — 702

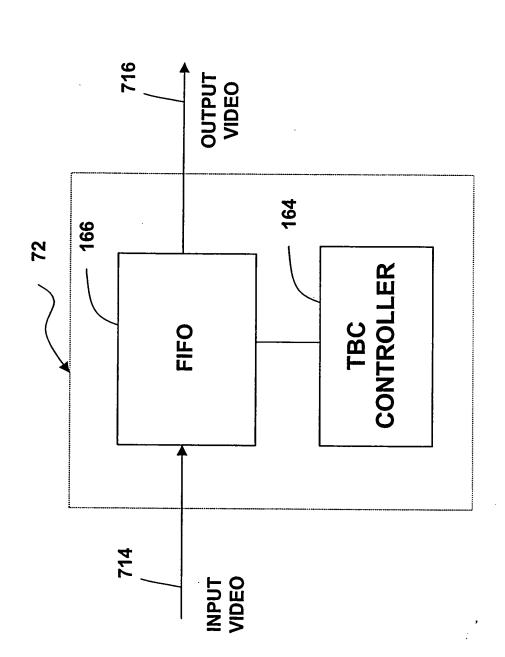712

LINE LOCKED SRC — 704

714

TIME BASE CORRECTOR — 72

FIG. 18

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 19 of 37

CHROMA-LOCKED SRC

FIG. 19

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
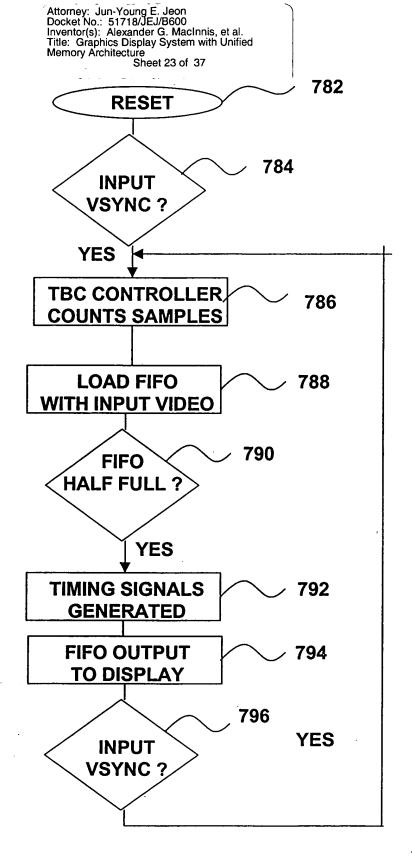Memory Architecture
Sheet 20 of 37

FIG. 20

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 21 of 37

704

714

780

YUV SCALER

770

SRC

772

HORIZONTAL SYNC TRACKER

712

LINE-LOCKED SRC

FIG. 21

716

OUTPUT
VIDEO

72

166
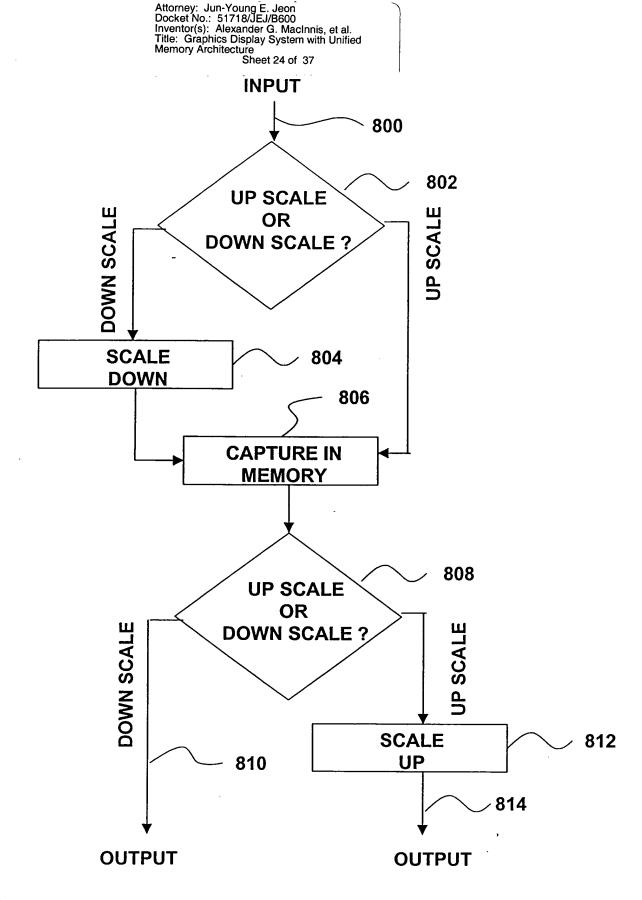
FIFO

164

TBC
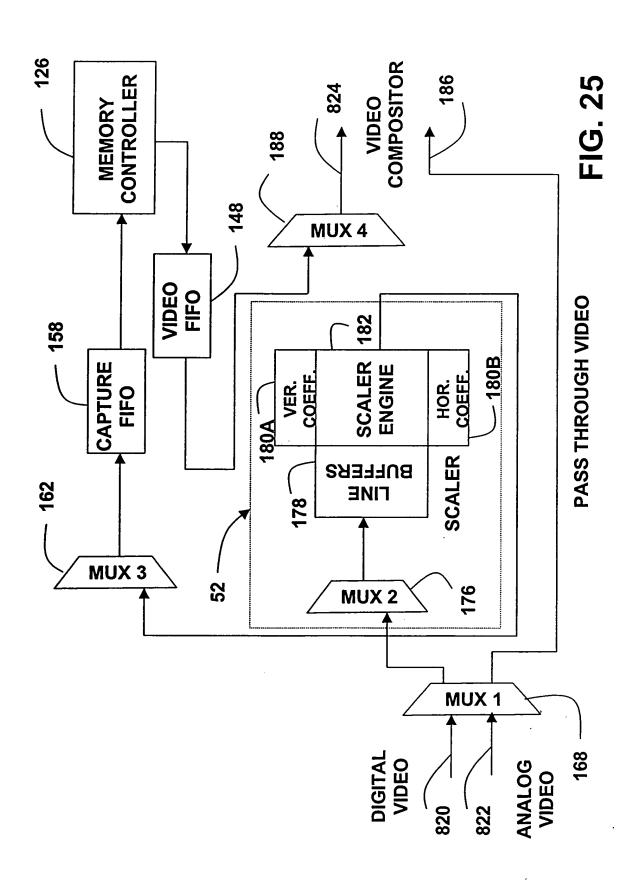CONTROLLER

714

INPUT
VIDEO

FIG. 22

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 23 of 37

RESET — 782

INPUT VSYNC ? — 784

YES

TBC CONTROLLER COUNTS SAMPLES — 786

LOAD FIFO WITH INPUT VIDEO — 788

FIFO HALF FULL ? — 790

YES

TIMING SIGNALS GENERATED — 792

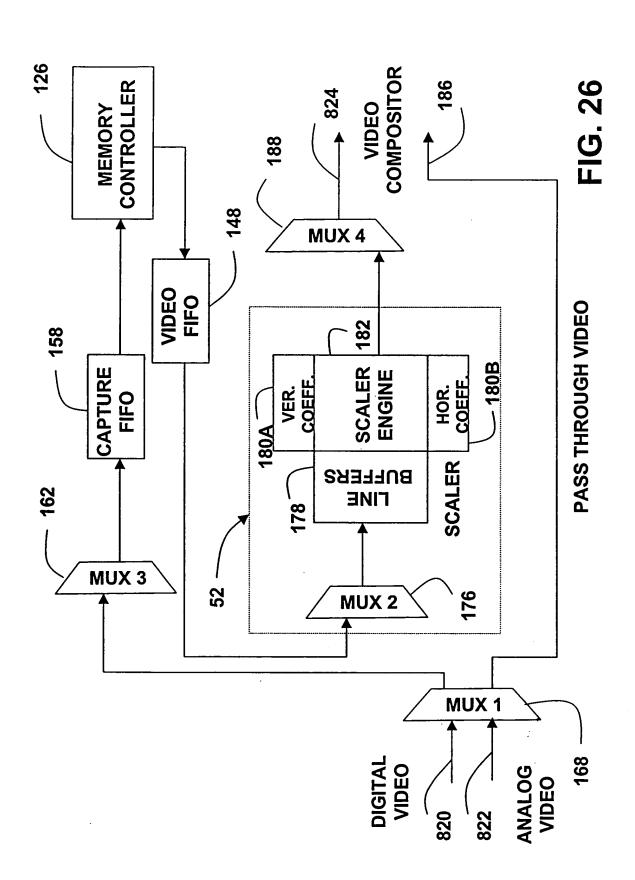FIFO OUTPUT TO DISPLAY — 794
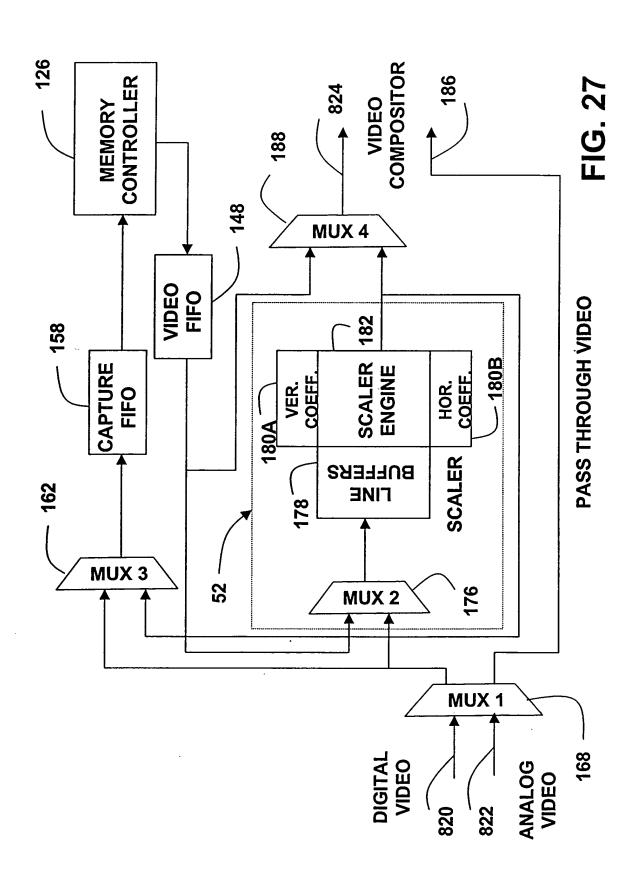
INPUT VSYNC ? — 796   YES

FIG. 23

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
                    Sheet 24 of 37

INPUT

800

UP SCALE
OR
DOWN SCALE ?

802

DOWN SCALE

UP SCALE

SCALE
DOWN

804

806

CAPTURE IN
MEMORY

UP SCALE
OR
DOWN SCALE ?

808

DOWN SCALE

UP SCALE

810

SCALE
UP

812

814

OUTPUT

OUTPUT

FIG. 24

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 25 of 37

FIG. 25

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 26 of 37

FIG. 26

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
                    Sheet 27 of 37

FIG. 27

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 28 of 37

RESET   902

BLEND GRAPHICS   904

FILTER
GRAPHICS WINDOW   906
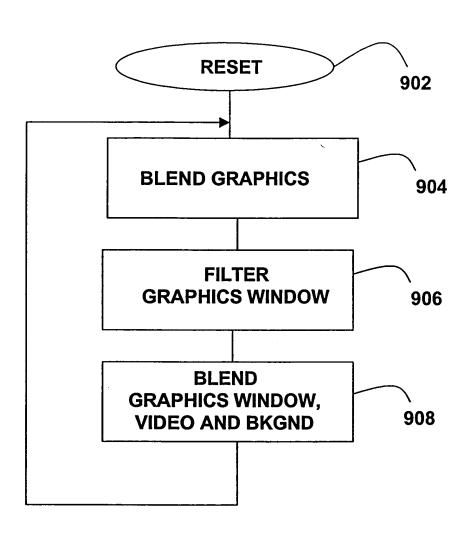
BLEND
GRAPHICS WINDOW,
VIDEO AND BKGND   908

FIG. 28

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 29 of 37

RESET — 920

VSYNC ? — 922

LOAD BOTTOM MOST WINDOW — 924

BLEND NEXT WINDOW — 926

LAST WINDOW ON LINE — 928

NO

YES

LAST LINE OF FIELD ? — 930
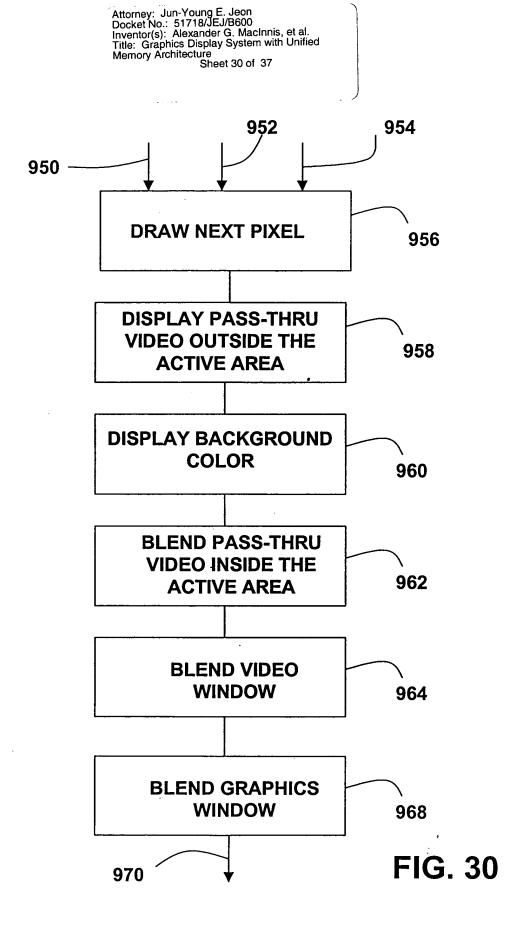
NO
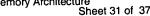
GO TO NEXT LINE — 932

YES

FIG. 29

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 30 of 37

950   952   954

DRAW NEXT PIXEL — 956

DISPLAY PASS-THRU VIDEO OUTSIDE THE ACTIVE AREA — 958

DISPLAY BACKGROUND COLOR — 960

BLEND PASS-THRU VIDEO INSIDE THE ACTIVE AREA — 962

BLEND VIDEO WINDOW — 964

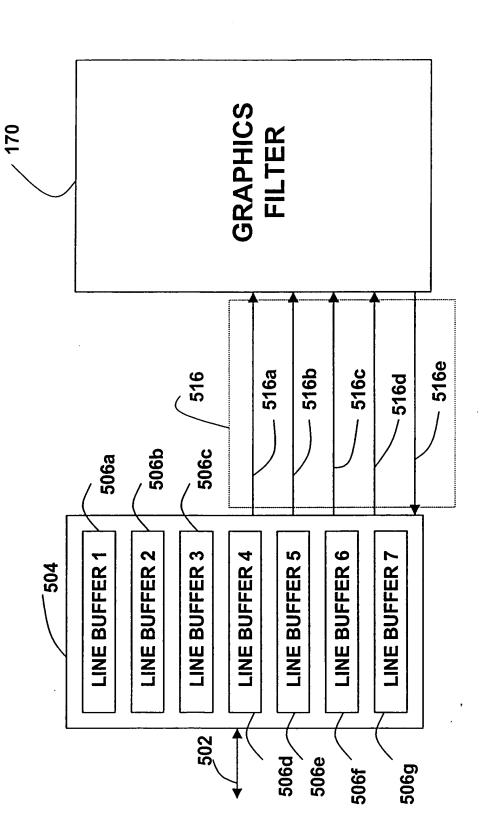**BLEND GRAPHICS WINDOW** — 968

970

FIG. 30

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
                    Sheet 31 of 37

170

GRAPHICS
FILTER

516

516a
516b
516c
516d
516e

506a
506b
506c

504

LINE BUFFER 1
LINE BUFFER 2
LINE BUFFER 3
LINE BUFFER 4
LINE BUFFER 5
LINE BUFFER 6
LINE BUFFER 7

502

506d
506e
506f
506g

FIG. 31

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 32 of 37

FIG.32

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 33 of 37

1132

1144

ARBITER

1130

TIMER BLOCK

1134a
1134b
1134c
1134d
1134e

TASK 1
TASK 2
TASK 3
TASK 4
TASK 5

1142

CPU REQUEST

1138

1136

SPORADIC SERVER

1140a
1140b
1140c
1140d

LOW PRIORITY TASKS IN ROUND ROBIN

FIG. 33

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
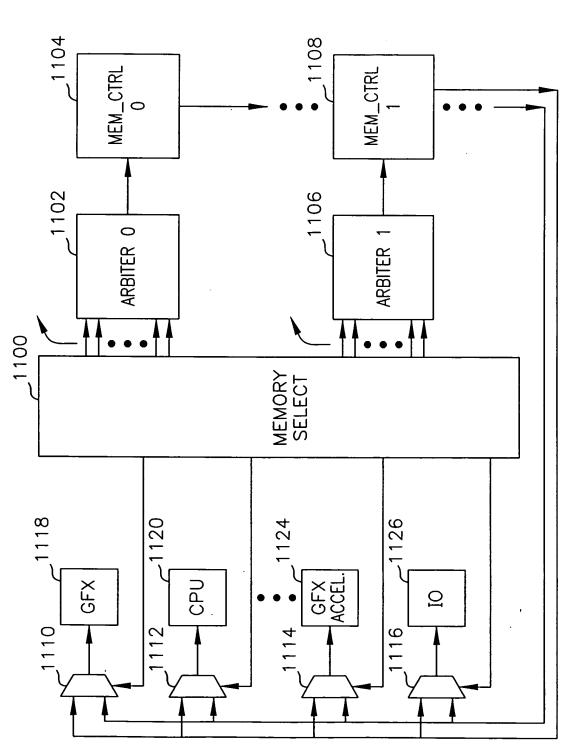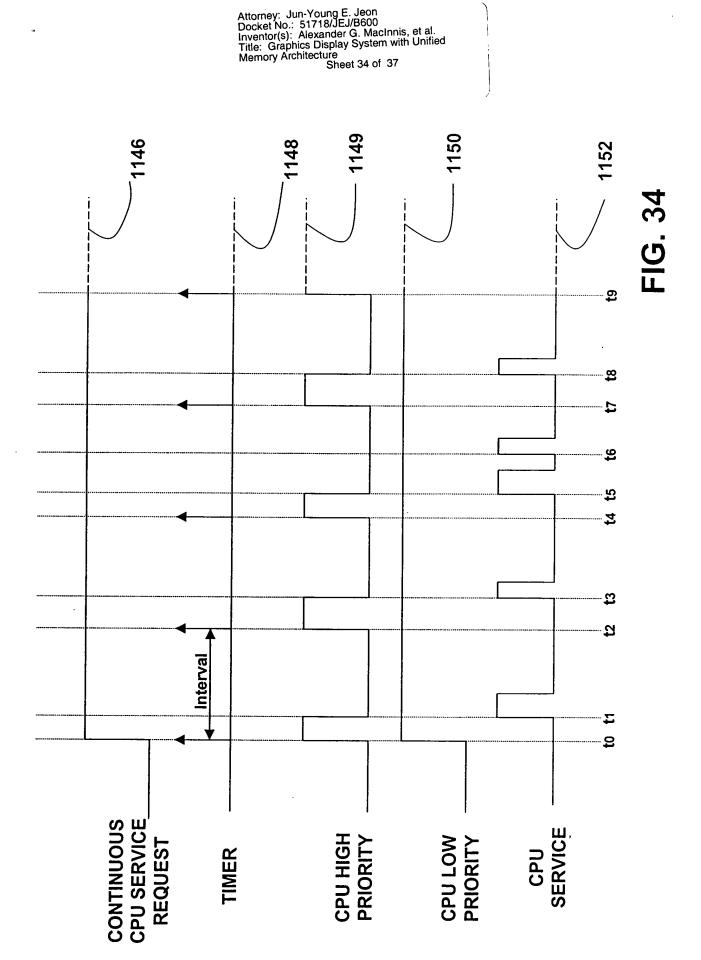Memory Architecture
Sheet 34 of 37

FIG. 34

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 35 of 37

LOW PRIORITY
TASK

1154

TASK 1

1156

TASK 2

1158

TASK 3

1160

TASK 4

1162

t0 t1 t2 t3 t4 t5 t6 t7 t8 t9

FIG. 35

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 36 of 37

HIGHEST PRIORITY

CPU READ REQUEST WITH BLOCKOUT COUNTER —1170

GFX/WD READ REQUEST WITH BLOCKOUT COUNTER —1172

ROUND ROBIN ARBITRATION FOR 2 CLIENTS

1174— VIDEO WINDOW READ REQUEST

VIDEO CAPTURE WRITE REQUEST —1176

REFRESH REQUEST —1178

AUDIO READ REQUEST —1180

ROUND ROBIN ARBITRATION FOR 5 CLIENTS

1182— CPU READ REQUEST

GFX ACCELERATOR REQ. —1184

1190— CPU WRITE REQUEST

GFX/WD READ REQUEST —1186

DMA READ/WRITE REQUEST —1188

FIG.36

LOWEST PRIORITY

Attorney: Jun-Young E. Jeon
Docket No.: 51718/JEJ/B600
Inventor(s): Alexander G. MacInnis, et al.
Title: Graphics Display System with Unified
Memory Architecture
Sheet 37 of 37

FIG. 37